COPING WITH A POWER FAILURE
AUTOROTATION ENTRY AND FLARE

The fact that a single-engine helicopter has a much better chance of making a safe landing following a power failure than a single-engine airplane probably comes up in more general discussions of rotorcraft than any other talking point. Despite some glowing descriptions, however, the maneuver does not occur automatically but requires some clever management of energy on the pilot’s part to bring it off without doing damage to man or machine.

Entry into autorotation

Failure to make a good entry into autorotation after the engine stops is one of the primary causes of helicopter accidents. The key to making a good entry is to keep the rotor speed up. If the rpm is allowed to decay too much, the rotor may stall and come to a fatal strop when asked to support the full weight of the helicopter. Even before reaching this point of no return, other bad things--like generators dropping off the line and hydraulic pressure going below minimums--may occur.

The reason for the rpm decay is that when the engine suddenly quits providing power, the rotor will begin to feed on its own energy by slowing down to make up for the power loss. If the rotor has high inertia because of heavy blades or tip weights, the rpm will fall off slower than if it were a lightweight rotor. The flight condition at the time of engine failure will also affect the rate of decay; a failure in a high-power climb will result in a faster decay than had it happened in level flight or a descent.

The accepted way to stop the decay is to quickly reduce the power demands on the rotor by lowering the collective stick. This results in an initial loss of thrust, but does get the helicopter going down through the air--the first prerequisite for autorotation. The upcoming air through the rotor will soon increase the thrust, even at low collective pitch. If the rotor speed has not dropped too far in the meantime, the pilot can maneuver the ship into steady autorotation with the thrust equal to the gross weight and the rotor speed controllable by small changes in collective--lowering the stick for increased speed and raising it to prevent overspeed. This procedure is associated with a substantial loss of altitude as potential energy is sacrificed to put kinetic energy back into the rotor.

There is an alternate procedure, however, that can work if the power failure has occurred at a moderately high forward speed. In this situation, the pilot can take advantage of the kinetic energy associated with forward speed by doing a mild cyclic flare before lowering the collective pitch. This puts the rotor into a nose-up attitude that reduces the decelerating torque and maintains thrust and altitude until the forward speed is decreased to the best autorotational speed. At that point the collective pitch is reduced for entry into autorotation.

I know of one test pilot who developed this technique on a UH-1 to the point where he could delay dropping the collective for nine seconds after the power chop. (I also know of one test pilot who takes exception to this alternative procedure. Bob Ferry, who worked for Hughes, says, “Always lower the collective pitch the very first thing! I know of several dead pilots who didn’t.”) Bob also makes the point that messing up the autorotative landing flare is usually not fatal, but messing up the autorotative entry almost always is.

Steady autorotation

During steady autorotation, the energy balance is achieved by the continuous loss of potential energy due to the aircraft’s descent. The resulting steady airflow up through the rotor produces enough power to satisfy the helicopter's flight requirements at that speed. The minimum rate of descent occurs at the speed for minimum power on the level-flight power-required curve. It is prudent, however, to autorotate at five or 10 knots faster than the bucket speed for the extra margin of kinetic energy available for increasing rotor speed in the landing flare.

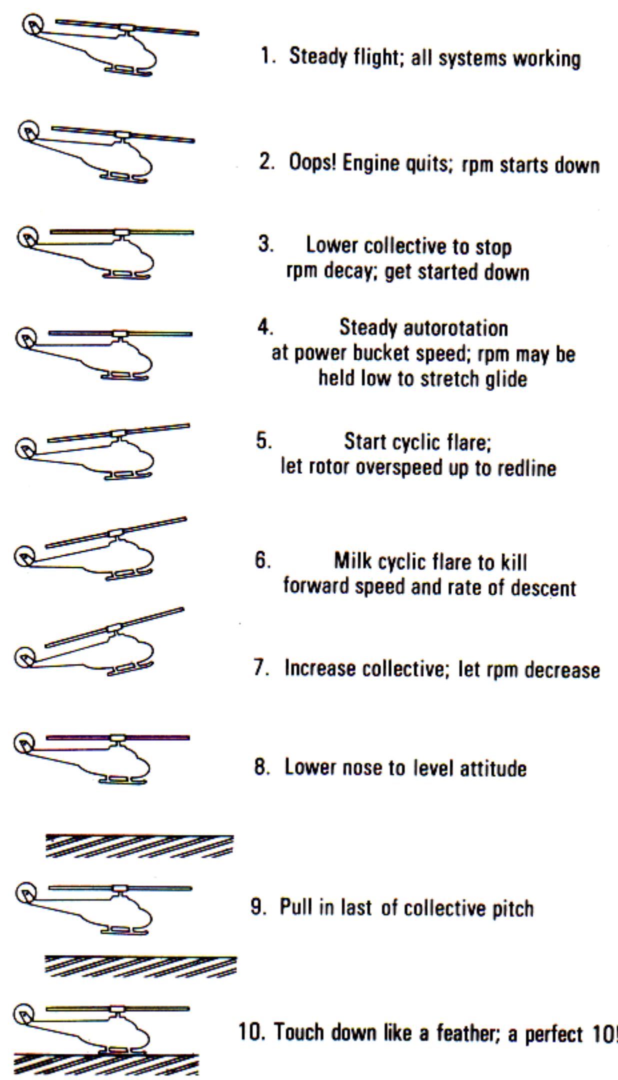
The landing flare

Even with the lowest possible rate of descent in steady autorotation, the helicopter is carrying far too much energy along its flight path for the landing gear to absorb at the moment of truth. Once again it is up to the pilot to cleverly manage his various energy sources to insure the touchdown will be within the capabilities of the landing gear.

In short, the problem becomes one of reducing the kinetic energy along the flight path to near zero just before making ground contact--while continually absorbing enough power from the passing air and from the stored kinetic energy to supply the requirements of flight--all without letting the rotor rpm droop to a stalling condition!

The solution is a maneuver starting with a well-timed cyclic nose-up flare that simultaneously increases the rotor thrust due to the increased angle of attack while tilting the rotor thrust vector aft, thus braking both the forward and vertical veloc- cities. It can also be used to store energy in the rotor in the form of an rpm overspeed--up to the rotor-speed redline. The extra rotor energy is not important for itself but for the time cushion it gives the pilot to correct nonoptimum control motions in the final critical seconds. (An Army report on the subject beautifully understates the situation when it says, "Pilot apprehension is a factor because of ground proximity and rate of closure.")

Landing After A Power Failure



Army tests on a UH-1C indicated that, at most, only 15% of the energy associated with the loss of altitude and forward speed could be converted into rotor energy during the flare. During the cyclic flare, a low-inertia rotor can be rapidly brought up to a state of high kinetic energy, making it comparable to a high-inertia rotor whose speed cannot be so rapidly increased.

The cyclic flare should continue until the helicopter slows down to 30 or 40 knots, where most of the available forward-flight kinetic energy has been used up. Now is the time to call on the rotational energy stored in the rotor by pulling up on collective pitch to maintain thrust as the rotor slows down. The Army tests on the UH-1C indicated that the rotor energy can be used for slowing the helicopter down with about a 25% efficiency. A final forward push on the cyclic stick should level the helicopter just before the landing gear touches down.

It is evident that the success of the landing flare depends on precise timing of the various pilot actions. This comes from practicing with the engine declutched but running--so that it is available to immediately add power if the timing is a little off. Unfortunately, even this precaution is not fool-proof and a number of helicopters are damaged every year while practicing landings from autorotation.

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